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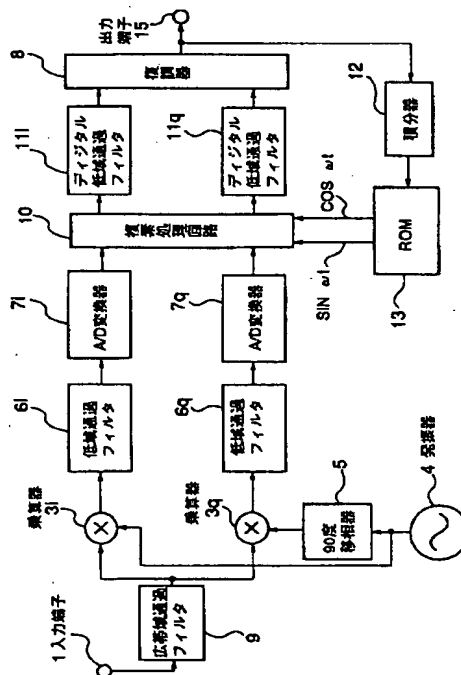
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(54)【発明の名称】 受信機

(57)【要約】

【目的】受信機において、広帯域なアナログフィルタで、帯域通過処理を行い、A/D変換後狭帯域なフィルタ処理を行うことにより、アナログフィルタの製造コストを押さえ、特性を補正するためのI Fフィルタ等化器が不要な回路が実現できる。また、検波方式をわずかに変えることにより、AM変調信号、FM変調信号に対応した検波をすることができる受信機を提供する。

【構成】本発明は、上記の目的を達成するために、図1、図5および、図6のようなブロック図で回路を構成する。I F帯の信号に周波数変換された信号を帯域通過フィルタにより帯域制限する手段を有し、A/D変換後に複素処理回路により、中心周波数のずれを補正し、デジタルフィルタにより、ベースバンド帯で狭帯域なフィルタ処理をし、復調出力を得る受信機。また、複素デジタル回路を用いることにより、I F周波数帯で狭帯域なフィルタ処理を行い、復調出力を得る受信機。



【特許請求の範囲】

【請求項1】 全通話チャンネルが通過域となるアナログ広帯域通過フィルタに受信信号を通し、直交した局発信信号を乗算して、直交する中間周波信号に周波数変換し、A/D変換したあと、デジタル的に狭帯域フィルタ処理を行い、復調出力を得ることを特徴とした受信機。

【請求項2】 請求項1記載の受信機において、A/D変換後に複素演算処理を行い、前記直交する中間周波信号に周波数変換する際に生ずる周波数ずれを補正することを特徴とした受信機。

【請求項3】 請求項1記載の受信機において、中間周波数に周波数変換した信号を複素デジタルフィルタによりフィルタ処理を行い、イメージ妨害成分を除去し復調出力を得ることを特徴とした受信機。

【請求項4】 IF帯の信号に周波数変換され受信信号を入力する入力端子と、該入力端子に入力した受信信号の全通話チャンネルが通過域となるアナログ広帯域フィルタと、該フィルタ通過後の信号を直交検波するための発振器および90度移相器ならびに同相成分、直交成分2つの乗算器と、該乗算器により検波された同相成分と直交成分の信号の高調波成分を除去するための同相成分、直交成分各々の低域通過フィルタと、該低域通過フィルタを通過した信号を各々デジタル変換するためのA/D変換器と、該A/D変換器からの同相、直交デジタル信号を複素処理する複素処理回路と、該複素処理回路により処理された同相成分、直交成分各々のデジタル信号を単通話チャンネル毎に選択する同相、直交各々の狭帯域のデジタル低域通過フィルタと、該両フィルタから出力される帯域制限された信号を復調して出力する復調器と、該復調器の出力を積分する積分器と、該積分器の出力に対応する位相情報データを読み出し、前記複素処理回路に出力するROMとを有し、該位相情報データにより前記複素処理回路の位置補正を行う構成としたことを特徴とする受信機。

【発明の詳細な説明】

【0001】

【発明の属する利用分野】 本発明は、デジタル信号処理技術を用いて、デジタル変調信号の復調を行う受信機に関するものである。

【0002】

【従来の技術】 従来の受信機の一例を図2のブロック図を用いて説明する。1は入力端子、2は帯域通過フィルタ、3iはIF帯信号の同相成分Iの乗算器、3qはIF帯信号の直交成分Qの乗算器、4は発振器、5は90度移相器、6iは同相成分の低域通過フィルタ、6qは直交成分の低域通過フィルタ、7はA/D変換器、8は復調器、15は出力端子である。受信信号はIF帯の信号に周波数変換してから入力端子1に入力し、帯域通過フィルタ2で帯域制限され、発振器4と90度移相器5によって発生した直交局部発振信号を乗算器3iと3qによって乗算し、

直交検波を行う。直交検波出力信号の同相成分Iと直交成分Qは低域通過フィルタ6iと6qに通して高調波成分を除去したあと、A/D変換器7iと7qでデジタル信号に変換する。その後復調器8により復調し、出力端子15に出力される。

【0003】

【発明が解決しようとする課題】 前述の従来例では、帯域通過フィルタは狭帯域なアナログフィルタを使用している。しかし、近年では通信需要の増大に伴い通話帯域幅を狭くする傾向にあり、帯域通過フィルタには平坦な通過域特性と急峻な遮断特性が要求されるが、通過域が狭帯域化するほどこれらのフィルタ特性を実現することが技術的に困難になる。そのためフィルタの製造コストが高くなり、また特性を補正するためのIFフィルタ等化器が必要となりさらに製造コストが高くなるという問題がある。また、広い通話チャンネルをカバーするため多数のフィルタを用意しなくてはならず、コストが増大するといった問題も生ずる。さらにフィルタの中心周波数がわずかに変動しても通話困難となるため、回路の安定度への要求も厳しくなる。

【0004】 本発明の目的は、これらの欠点を除去し、安価で高精度な受信機を提供することである。

【0005】

【課題を解決するための手段】 本発明は上記の目的を達成するために、全通話チャンネルを通過域とする広帯域なアナログ帯域通過フィルタを用い、周波数変換した後A/D変換し、デジタル複素信号処理により狭帯域なフィルタ処理を行うことにより受信機を構成したものである。

【0006】

【発明の実施の形態】 以下、本発明の一実施例を図1を用いて説明する。1は入力端子、9は広帯域通過フィルタ、3iはIF帯信号の同相成分Iの乗算器、3qはIF帯信号の直交成分Iの乗算器、4は発振器、5は90度移相器、6iは同相成分の低域通過フィルタ、6qは直交成分の低域通過フィルタ、7はA/D変換器、10は複素処理回路、11iは同相成分のデジタル低域通過フィルタ、11qは直交成分のデジタル低域通過フィルタ、12は積分器、13は読み込み専用のメモリ（ROM）、8は復調器、15は出力端子である。受信信号はIF帯の信号に周波数変換してから入力端子1に入力し、広帯域通過フィルタ9で帯域制限され、発振器4と90度移相器5によって発生した直交局部発振信号を乗算器3iと3qによって受信信号に乗算し、ベースバンド帯で直交検波を行う。直交検波出力は低域通過フィルタ6iと6qに通して高調波成分を除去したあと、A/D変換器7iと7qでデジタル信号に変換し、複素処理回路10で複素演算処理を行い、デジタル低域通過フィルタ11iと11qで、狭帯域な帯域制限を行う。その後復調器8により復調し、出力端子15に出力される。ここで発振器4は復調器8と

同期がとれておらず、広帯域通過フィルタ9を使用しているため、例えば図4のような周波数のずれが生ずる。このため、復調器8の出力を積分器12を通しROM13に貯え、複素処理回路10にフィードバックすることにより、位相の回転を止め、中心周波数を合わせる準同期検

$$I' = I \cos \omega t - Q \sin \omega t \quad Q' = Q \cos \omega t + I \sin \omega t \quad \cdots \text{式(1)}$$

ここで I' は同相成分の複素処理回路出力、 Q' は直交成分の複素処理回路出力、 I は同相成分の複素処理回路入力、 Q は直交成分の複素処理回路入力である。また本発明の応用例として図1の発振器4を電圧制御発振器で構成した場合には、復調器8の出力を発振器4にフィードバックすることにより同期をとることができ、複素処理回路10を省略することができる。以上の動作により、広帯域なアナログフィルタとデジタル処理による狭帯域なフィルタ処理の組合わせにより高精度な受信機出力を得ることが可能となる。なお、前記実施例は直接検波方式に適用したもので、AM変調波を検波するのに適している。

【0007】次に本発明の第二の実施例を、図5を用いて説明する。図5はヘテロダイン検波方式に本発明を適用した一例で、1は入力端子、9は広帯域通過フィルタ、3iはIF帯信号の同相成分Iの乗算器、3qはIF帯信号の直交成分Iの乗算器、4は発振器、5は90度移相器、6iは同相成分の低域通過フィルタ、6qは直交成分の低域通過フィルタ、7iと7qはA/D変換器、14は複素デジタルフィルタ、8は復調器、15は出力端子である。受信信号はIF帯の信号に周波数変換してから入力端子1に入力し、広帯域通過フィルタ9で帯域制限する。発振器4と90度移相器5によって発生した直交局部発振信号を乗算器3iと3qによって受信信号に乗算し、ベースバンド帯で直交検波を行う。この直交検波出力は低域

$$H_0(Z) = a_0 + a_1 Z^{-1} + a_2 Z^{-2} + \cdots + a_n Z^{-n}$$

ここで $Z = e^{j2\pi f/fs}$ (f_s : サンプル周波数) である。フィルタの中心周波数を f_c とすると、 f_c を f_c

$$Z = e^{j2\pi (f-f_c)/fs} = e^{j2\pi f/fs} \cdot e^{-j2\pi f_c/fs}$$

$$= Z \cdot e^{-j2\pi f_c/fs} = Z \cdot \alpha \quad (f_s: \text{サンプル周波数}) \quad \cdots \text{式(4)}$$

ここで、 $\alpha = e^{-j2\pi f_c/fs}$ は絶対値が1の複素数であ

$$H_0(Z) = a_0 + a_1 \alpha^{-1} Z^{-1} + a_2 \alpha^{-2} Z^{-2} + \cdots + a_n \alpha^{-n} Z^{-n}$$

$$= H_{r0} + jH_{i0} + (H_{r1} + jH_{i1}) Z^{-1} + (H_{r2} + jH_{i2}) Z^{-2} + \cdots + (H_{rn} + jH_{in}) Z^{-n} \quad \cdots \text{式(5)}$$

となり、複素係数フィルタが得られる。この複素係数フィルタの構成を示す図が図6である。また、周波数シフトされた複素デジタルフィルタの周波数特性が図9である。複素フィルタであるため通過域は正負周波数のどちらか一方(図9では正の周波数側)だけとなる。図10は、複素デジタルフィルタの出力でイメージ妨害成分は複素フィルタで除去されている。アナログフィルタを広帯域にしているため、IF信号にはイメージ妨害成分が重なるが、複素デジタルフィルタ処理により、このイメージ妨害成分を除去し、かつ狭帯域なフィルタリン

波により、複素処理出力を得ている。複素処理回路10の内部構成の一例を図3に示す。複素処理回路10は、乗算器16i-1, 16i-2, 16q-1, 16q-2と加算器17i, 17qで構成され、その動作は式(1)のようになる。

通過フィルタ6iと6qを通して高調波成分を除去したあと、A/D変換器7iと7qでデジタル信号に変換し、複素デジタルフィルタ14によりフィルタ処理を行う。複素デジタルフィルタ14の構成の一例を図6に示す。17i~26iと17q~26qは乗算器で、27i~29iと27q~29qは加算器で、30i~33iと30q~33qは遅延レジスタである。フィルタ処理を式で表すと、次の式(2)のようになる。

$$Y_i = H_{ri} I - H_{qi} Q \quad Y_q = H_{ri} Q + H_{qi} I \quad \cdots \text{式(2)}$$

ここで、

Y_i, Y_q : デジタル複素フィルタ出力、

H_i, H_r : フィルタ係数、

I, Q : フィルタ入力信号

である。図6の複素デジタルフィルタ14の動作を図7、図8、図9、図10のスペクトル図を用いて説明する。図7は、複素フィルタ処理前の信号、つまりA/D変換器7iと7qの出力IとQである。ここで周波数 f_c と周波数 $-f_c$ に信号が現れているが、求める信号は一方だけ(ここでは $+f_c$ の成分とする)で $-f_c$ の成分はイメージ妨害信号となる。このイメージ妨害を除去するには、図9に示すような正の周波数域にのみ通過域を持つ複素係数フィルタが必要である。この複素係数フィルタは、図8のような実係数フィルタの周波数特性を $+f_c$ だけ周波数シフトすることにより得られる。図8のフィルタを、式で表すと次の式(3)のようになる。

$$(a_0 \sim a_n): \text{フィルタ係数} \quad \cdots \text{式(3)}$$

にシフトするため f_c を基準とする周波数 f は $(f-f_c)$ にシフトされる。よって

る。式(4)を式(3)に代入して整理すると

グが可能となる。なお、この実施例は、FM変調波を検波するのに適している。

【0008】以上のように、デジタルフィルタで狭帯域フィルタを実現することは、周波数変換後のサンプル周波数がそれほど高くなければ、容易である。また1度設計した後はアナログ回路のような調整作業は不要で、コストがほとんどかからない。

【0009】

【発明の効果】本発明によれば、広帯域なアナログフィルタを用い、A/D変換後、狭帯域なデジタルフィル

タ処理をすることにより、コストが大幅に削減できる受信機が実現できる。

【図面の簡単な説明】

【図1】 本発明の一実施例を示すブロック図

【図2】 従来の技術を示すブロック図

【図3】 複素処理回路の一実施例を示す内部構造図

【図4】 中心周波数のずれによるベースバンド信号の一実施例を示すスペクトル図

【図5】 本発明の一実施例を示すブロック図

【図6】 複素デジタルフィルタの内部構造の一実施例を示すブロック図

【図7】 A/D変換器からの出力信号の一例を示すスペクトル図

【図8】 複素デジタルフィルタの周波数特性（ベースバンド帯）の一例を示すスペクトル図

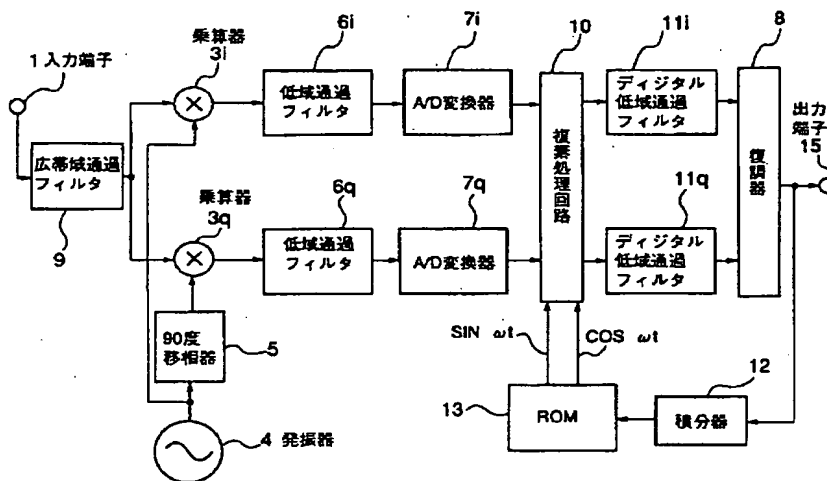
【図9】 周波数シフト後の複素デジタルフィルタの周波数特性の一例を示すスペクトル図

【図10】 複素デジタルフィルタの出力信号の一例を示すスペクトル図

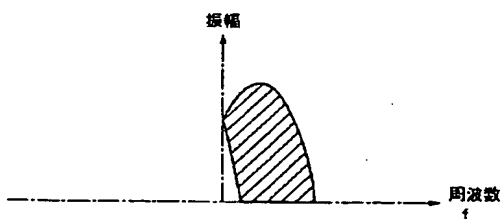
【符号の説明】

1:入力端子、2:帯域通過フィルタ、3i, 3q:乗算器、4:発振器、5:90度移相器、6i, 6q:低域通過フィルタ、7i, 7q:A/D変換器、8:復調器、9:広帯域通過フィルタ、10:複素処理回路、11i, 11q:デジタル低域通過フィルタ、12:積分器、13:ROM、14:複素デジタルフィルタ、15:受信機出力、16i-1, 16i-2, 16q-1, 16q-2:乗算器、17i~26i, 17q~26q:乗算器、27i~29i, 27q~29q:加算器、30i~33i, 30q~33q:遅延レジスタ。

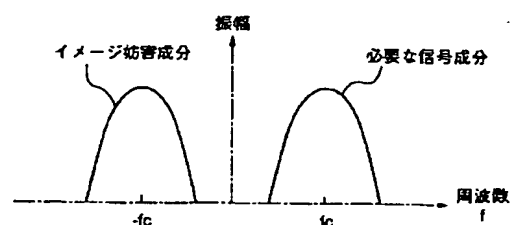
【図1】



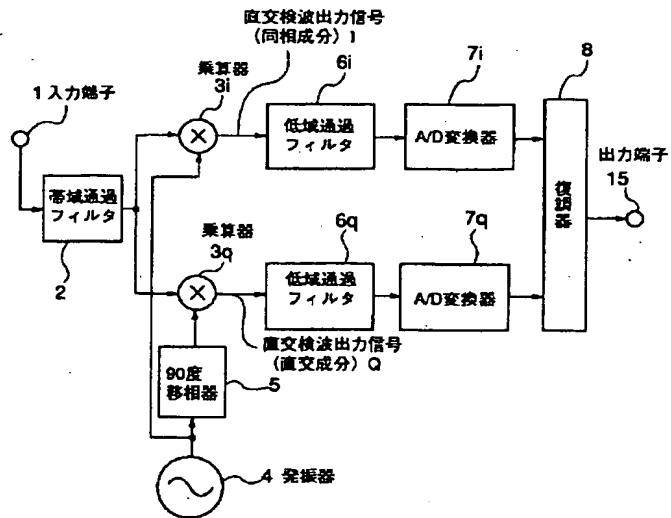
【図4】



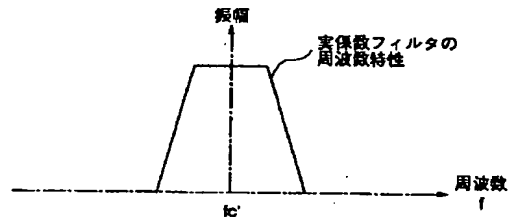
【図7】



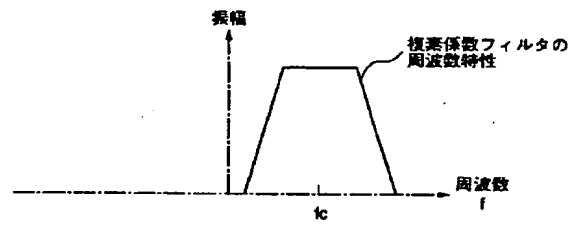
【図2】



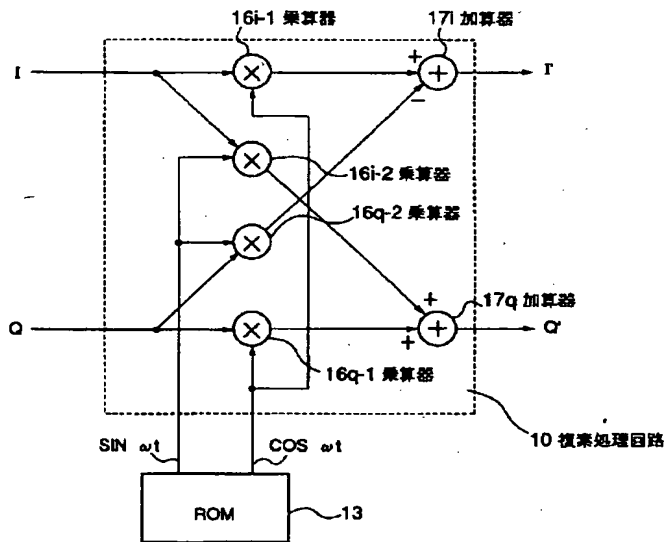
【図8】



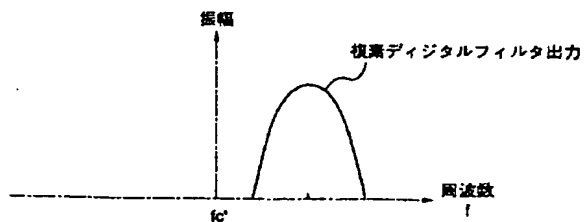
【図9】



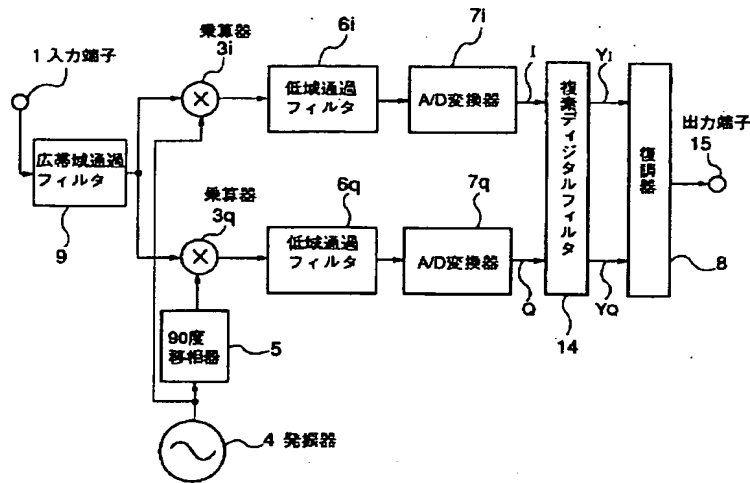
【図3】



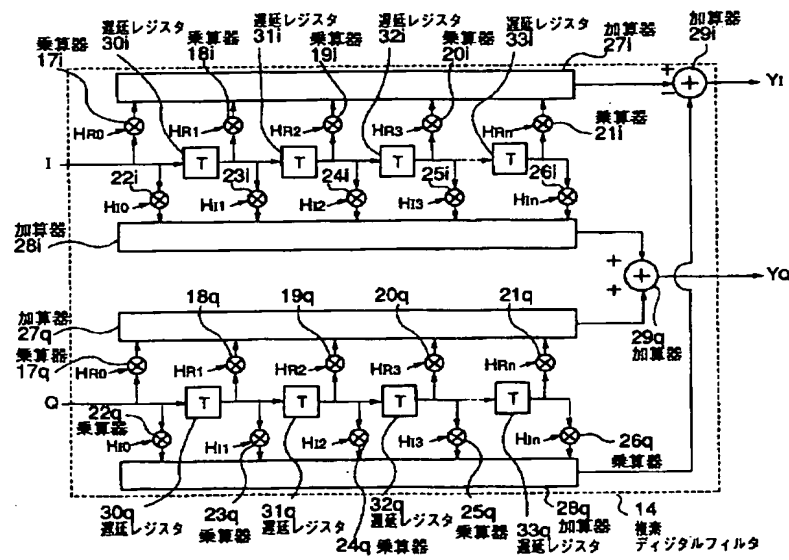
【図10】



【図5】



【図6】



PATENT ABSTRACTS OF JAPAN

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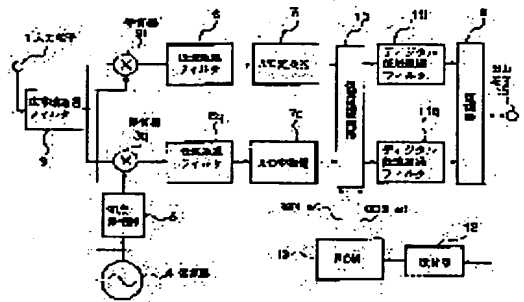
(21)Application number : 09-008220 (71)Applicant : HITACHI DENSHI LTD
(22)Date of filing : 21.01.1997 (72)Inventor : WAKAI HIROTAKE
ONISHI MAKOTO

(54) RECEIVER

(57)Abstract:

PROBLEM TO BE SOLVED: To ensure the stable calls with no increase of the cost by using a wide analog band filter which has its pass areas of all speech channels to perform the A/D conversion after the frequency conversion and to perform the narrow band filter processing via the digital complex signal processing.

SOLUTION: The received signal undergoes the frequency conversion into an IF band signal which is inputted to an input terminal 1 to undergo the band limitation via a wide band pass filter 9. Then the received signal is multiplied by the DC local oscillation signal produced by an oscillator 4 and a 90-degree phase shifter 5 via the multipliers 3i and 3q. The multiplied signal undergoes the DC detection at a base band, and the detection output is transmitted through the low band pass filters 6i and 6q for elimination of the higher harmonic components. Then the received signal is converted a digital signal by the A/D converters 7i and 7q. The digital signal undergoes the arithmetic processing via a complex processing circuit 10 and then undergoes the narrow band limitation via the digital low band pass filters 11i and 11q. Then the digital signal is demodulated by a demodulator 8 and outputted to an output terminal 15. Thus, no IF filter equalizer is required for correction of the characteristic.



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CLAIMS

[Claim(s)]

[Claim 1] The receiver characterized by performing narrow band filter processing in digital one, and obtaining a recovery output after it carries out the multiplication of through and the office dispatch number which intersected perpendicularly, and an opening-of-the-whole-traffic talk channel carries out frequency conversion of the input signal to the intermediate frequency signal which intersects perpendicularly and carries out A/D conversion to the analog wide band passage filter used as a passage region.

[Claim 2] the frequency drift which performs complex data processing after A/D conversion, and is produced in a receiver according to claim 1 in case frequency conversion is carried out to the aforementioned intermediate frequency signal which carries out a rectangular cross -- an amendment -- the receiver characterized by things

[Claim 3] The receiver characterized by for a complex digital filter performing filtering for the signal which carried out frequency conversion to the intermediate frequency in a receiver according to claim 1, removing an image disturbance component, and obtaining a recovery output.

[Claim 4] The receiver which is equipped with the following and characterized by considering as the composition which performs position amendment of the aforementioned complex processing circuit with these topology data. The input terminal which frequency conversion is carried out to the signal of IF band, and inputs an input signal. The analog broad band filter from which the opening-of-the-whole-traffic talk channel of an input signal inputted into this input terminal serves as a passage region. It is the multiplier of an in-phase component and two quadrature components to the VCO and the 90-degree phase-shifter row for carrying out rectangular detection of the signal after this filter passage. with the low pass filter of the in-phase component for removing the harmonic content of the signal of the in-phase component detected by this multiplier, and a quadrature component, and each quadrature component The A/D converter for carrying out digital conversion of the signal which passed this low pass filter respectively, The inphase from this A/D converter, and the complex processing circuit which carries out complex processing of the rectangular digital signal, with the inphase and the digital low pass filter of the narrow-band of each rectangular cross which choose the digital signal of the in-phase component processed by this complex circuit and each quadrature component for every single message channel ROM which reads the topology data corresponding to the output of the demodulator which restores to it and outputs the band-limited signal which is outputted from both these filters, the integrator which integrates with the output of this demodulator, and this integrator, and is outputted to the aforementioned complex processing circuit.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The field of the invention to which invention belongs] this invention relates to the receiver which restores to a digital modulation signal using digital-signal-processing technology.

[0002]

[Description of the Prior Art] An example of the conventional receiver is explained using the block diagram of drawing 2. 1 -- an input terminal and 2 -- a band-pass filter and 3i -- the multiplier of the in-phase component I of IF band signal, and 3q -- the multiplier of the quadrature component Q of IF band signal, and 4 -- for the low pass filter of an in-phase component, and 6q, as for an A/D converter and 8, the low pass filter of a quadrature component and 7 are VCO and 5 / a 90 degree phase shifter and 6i / a demodulator and 15] output terminals After carrying out frequency conversion of the input signal to the signal of IF band, it is inputted into an input terminal 1, it is band-limited by the band-pass filter 2, carries out the multiplication of the rectangular local oscillation signal generated with VCO 4 and the 90-degree phase shifter 5 with Multipliers 3i and 3q, and performs rectangular detection. After it lets the in-phase component I and quadrature component Q of a rectangular detection output signal pass to low pass filters 6i and 6q and they remove a harmonic content, they are changed into a digital signal by A/D converters 7i and 7q. It gets over by the demodulator 8 after that, and is outputted to an output terminal 15.

[0003]

[Problem(s) to be Solved by the Invention] In the above-mentioned conventional example, the band-pass filter is using the narrow-band analog filter. However, although it is in the inclination which narrows telephone call bandwidth with increase of communication need and a flat passage region property and a steep barrier property are required of a band-pass filter in recent years, it becomes difficult technically to realize these filter shapes, so that a passage region narrow-band-izes. Therefore, there is a problem that the manufacturing cost of a filter becomes high, and the IF-filter equalizer of an amendment sake is needed in a property, and a manufacturing cost becomes high further. Moreover, since a latus message channel is covered, many filters must be prepared, and the problem that cost increases is also produced. Since talking over the telephone becomes difficult even if it furthermore changes center of filter frequency slightly, the demand to the stability of a circuit also becomes severe.

[0004] The purpose of this invention is removing these faults and offering a cheap and highly precise receiver.

[0005]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, after this invention carries out frequency conversion of the opening-of-the-whole-traffic talk channel using the wide band analog band-pass filter made into a passage region, A/D conversion of it is carried out, and it constitutes a receiver by performing narrow-band filtering by digital complex signal processing.

[0006]

[Embodiments of the Invention] Hereafter, one example of this invention is explained using drawing 1. 1 a wide band passage filter and 3i for an input terminal and 9 The multiplier of the in-phase component I of IF band signal, 3q VCO and 5 for the multiplier of the quadrature component Q of IF band signal, and 4 A 90-degree phase shifter, The low pass filter of an in-phase component and 6q 6i The low pass filter of a quadrature component, In 7, the digital low pass filter of an in-phase component and 11q read a complex processing circuit and 11i, an A/D converter and 10 read an integrator and 13 for the digital low pass filter of a quadrature component, and 12, and, as for the memory (ROM) of exclusive use, and 8, a demodulator and 15 are output terminals. After carrying out frequency conversion of the input signal to the signal of IF band, it is inputted into an input terminal 1, it is band-limited by the wide band passage filter 9, carries out the multiplication of the rectangular local oscillation signal generated with VCO 4 and the 90-degree phase shifter 5 to an input signal with Multipliers 3i and 3q, and performs rectangular detection with a baseband band. After it lets it pass to low pass filters 6i and 6q and it removes a harmonic content, a rectangular detection output is changed into a digital signal by A/D converters 7i and 7q, performs complex data processing in the complex processing circuit 10, are the digital low pass filters 11i and 11q, and performs a narrow-band band limit. It gets over by the demodulator 8 after that, and is outputted to an output terminal 15. Since VCO 4 cannot take a demodulator 8 and a synchronization but is using the wide band passage filter 9, a gap of frequency like drawing 4 produces it here. For this reason, by storing an integrator 12 in through ROM13, and feeding back the output of a demodulator 8 to the complex processing circuit 10, rotation of a phase was stopped and the complex processing output has been obtained by the quasi-synchronous detection which doubles center frequency. An example of the internal configuration of the complex processing circuit 10 is shown in drawing 3. The complex processing circuit 10 consists of multiplier 16i-1, 16i-2, 16q-1, 16q-2, and adders 17i and 17q, and the operation becomes like a formula (1).

$I' = I \cos \omega t - Q \sin \omega t$ $Q' = Q \cos \omega t + I \sin \omega t$ -- formula (1) For I', the complex processing circuit output of an in-phase component and Q' are [the complex processing circuit input of an in-phase component and Q of the complex processing circuit output of a quadrature component and I] the complex processing circuit inputs of a quadrature component here. Moreover, when VCO 4 of drawing 1 is constituted from a voltage controlled oscillator as an application of this invention, by feeding back the output of a demodulator 8 to VCO 4, a synchronization can be taken and the complex processing circuit 10 can be omitted. The above operation enables it to obtain a highly precise receiver output with the combination of narrow-band filtering by the wide band analog filter and digital processing. In addition, the aforementioned example is what was applied to the direct detection method, and is suitable for detecting

[0007] Next, the second example of this invention is explained using drawing 5. an example with which drawing 5 applied this invention to the heterodyne-detection method -- it is -- 1 -- an input terminal and 9 -- a wide band passage filter and 3i -- the multiplier of the in-phase component I of IF band signal, and 3q -- the multiplier of the quadrature component I of IF band signal, and 4 -- VCO and 5 -- for the low pass filter of a quadrature component, and 7i and 7q, as for a complex digital filter and 8, an A/D converter and 14 are [a 90 degree phase shifter and 6i] After carrying out frequency conversion of the input signal to the signal of IF band, it is inputted into an input terminal 1, and the wide band passage filter 9 band-limits it. The multiplication of the rectangular local oscillation signal generated with VCO 4 and the 90-degree phase shifter 5 is carried out to an input signal with Multipliers 3i and 3q, and a baseband band performs rectangular detection. After this rectangular detection output removes a harmonic content through low pass filters 6i and 6q, it is changed into a digital signal by A/D converters 7i and 7q, and performs filtering by the complex digital filter 14. An example of the composition of the complex digital filter 14 is shown in drawing 6. 17i-26i, and 17q-26q are multipliers, 27i-29i, and 27q-29q are adders, and 30i-33i, and 30q-33q are delay registers. If filtering is expressed with a formula, it will become like the following formula (2).
$$YI=HRI-HIQ \quad YQ=HRQ+HII$$
 -- formula (2) Here, they are YI, a YQ: digital complex filter output, HI, HR: filter factor, I, and Q. : Filter input signal

It comes out. Operation of the complex digital filter 14 of drawing 6 is explained using drawing 7, drawing 8, drawing 9, and the spectrum view of drawing 10. Drawing 7 is the signal I and Q before complex filtering, i.e., the outputs of A/D converters 7i and 7q. They are frequency f_c and frequency here. Only for one side, the signal searched for although the signal has appeared in $-f_c$ is (here, it considers as the component of $+f_c$). – The component of f_c serves as an image disturbance signal. In order to remove this image disturbance, the complex coefficient filter which has a passage region only in a positive frequency region as shown in drawing 9 is required. This complex coefficient filter is obtained when only $+f_c$ carries out the frequency shift of the frequency characteristic of a real coefficient filter like drawing 8. If the filter of drawing 8 is expressed with a formula, it will become like the following formula (3).

$H_0(Z) = a_0 + a_1 Z^{-1} + a_2 Z^{-2} + \dots + a_n Z^{-n}$ ($a_0 - a_n$) : filter factor — Formula (3) Here It is $Z = e^{j2\pi f / f_s}$ (f_s : sampling frequency). If center of filter frequency is made into f_c' , in order to shift f_c' to f_c , the frequency f on the basis of f_c' will be shifted to $(f - f_c)$. It depends, $Z = e^{j2\pi(f - f_c) / f_s} = e^{j2\pi f / f_s}$ and $e^{-j2\pi f_c / f_s} = Z^{-1}$ (f_s : sampling frequency) — Formula (4) Here, the absolute value of $\alpha = e^{-j2\pi f_c / f_s}$ is the complex of 1. If a formula (4) is substituted for a formula (3) and arranged $H_0(Z) = a_0 + a_1 \alpha - 1 Z^{-1} + a_2 \alpha^2 - 2 Z^{-2} + \dots + a_n \alpha^n - n Z^{-n} = HR_0 + jHI_0 + (HR_1 + jHI_1) Z^{-1} + (HR_2 + jHI_2) Z^{-2} + \dots + (HR_n + jHI_n) Z^{-n}$ — It becomes a formula (5) and a complex coefficient filter is obtained. Drawing showing the composition of this complex coefficient filter is drawing 6. Moreover, the frequency characteristic of the complex digital filter by which the frequency shift was carried out is drawing 9. Since it is a complex filter, a passage region serves as only one of the positive/negative frequency (frequency side positive in drawing 9). Drawing 10 is removed with the output of a complex digital filter, and the image disturbance component is removed by the complex filter. Since the analog filter is made into the wide band, although an image disturbance component laps with an IF signal, by complex digital filter processing, this image disturbance component is removed and narrow-band filtering is attained. In addition, this example is suitable for detecting FM modulated wave.

[0008] As mentioned above, it is easy to realize a narrow band filter by the digital filter if the sampling frequency after frequency conversion is not so high. Moreover, after designing once, tuning like an analog circuit is unnecessary and hardly requires cost.

[Effect of the Invention] According to this invention, the receiver which cost can cut down sharply is realizable by carrying out narrow-band digital filter processing after A/D conversion using a wide band analog filter.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

- [Drawing 1] The block diagram showing one example of this invention
[Drawing 2] The block diagram showing a Prior art
[Drawing 3] The internal structure view showing one example of a complex processing circuit
[Drawing 4] The spectrum view showing one example of the baseband signaling by gap of center frequency
[Drawing 5] The block diagram showing one example of this invention
[Drawing 6] The block diagram showing one example of the internal structure of a complex digital filter
[Drawing 7] The spectrum view showing an example of the output signal from an A/D converter
[Drawing 8] The spectrum view showing an example of the frequency characteristic (baseband band) of a complex digital filter
[Drawing 9] The spectrum view showing an example of the frequency characteristic of the complex digital filter after a frequency shift
[Drawing 10] The spectrum view showing an example of the output signal of a complex digital filter

[Description of Notations]

1: Input terminal 2: Band-pass filter 3i, 3q : [Multiplier,] 4: VCO, 5:90-degree phase shifter 6i, 6q : [Low pass filter,] 7i, 7q: A/D converter 8: Demodulator 9 : [Wide band passage filter,] 10: Complex processing circuit 11i, 11q : [Digital low pass filter,] 12: Integrator 13:ROM 14 : [Complex digital filter,] 15: Receiver output 16i-1, 16i-2, 16q-1, 16q-2: Multiplier 17i-26i, 17q-26q: Multiplier 27i-29i, 27q-29q: Adder 30i-33i, 30q-33q: Delay register.

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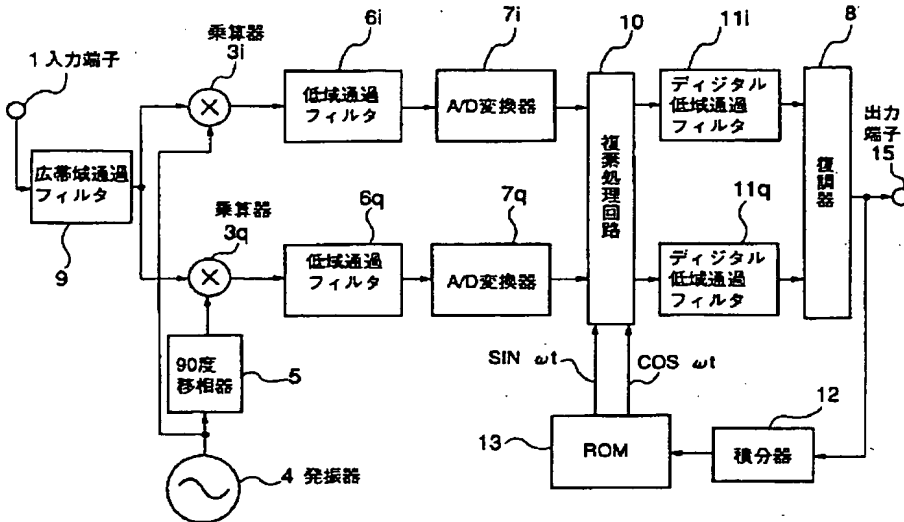
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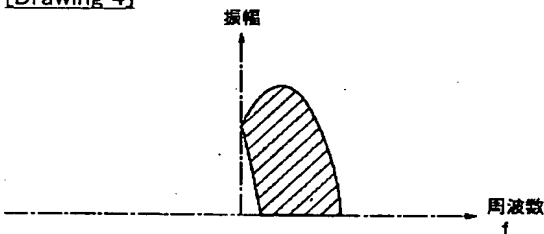
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DRAWINGS

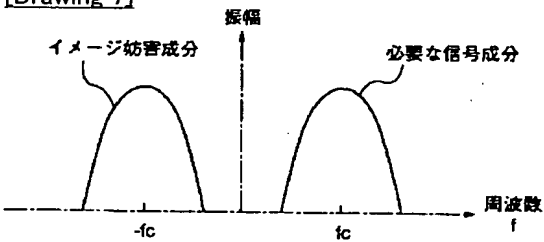
[Drawing 1]



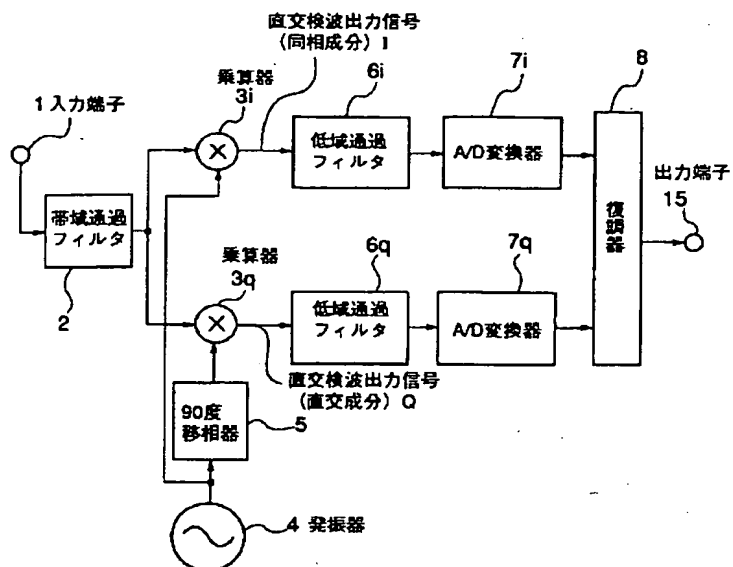
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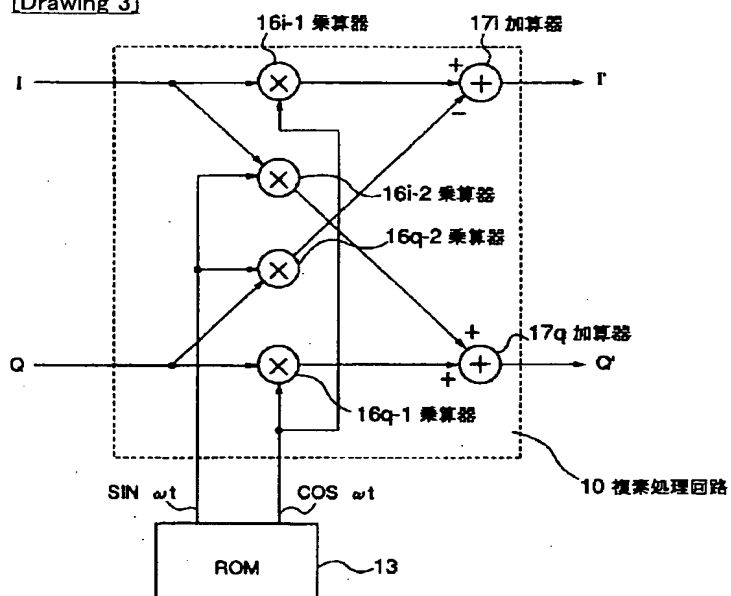
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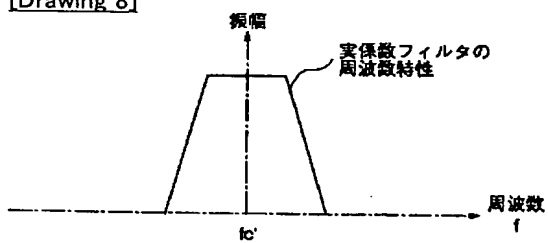
[Drawing 2]



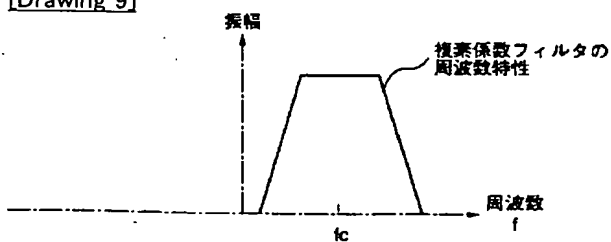
[Drawing 3]



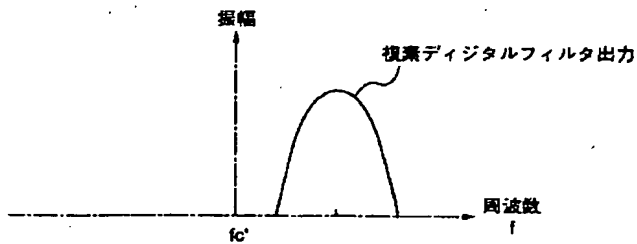
[Drawing 8]



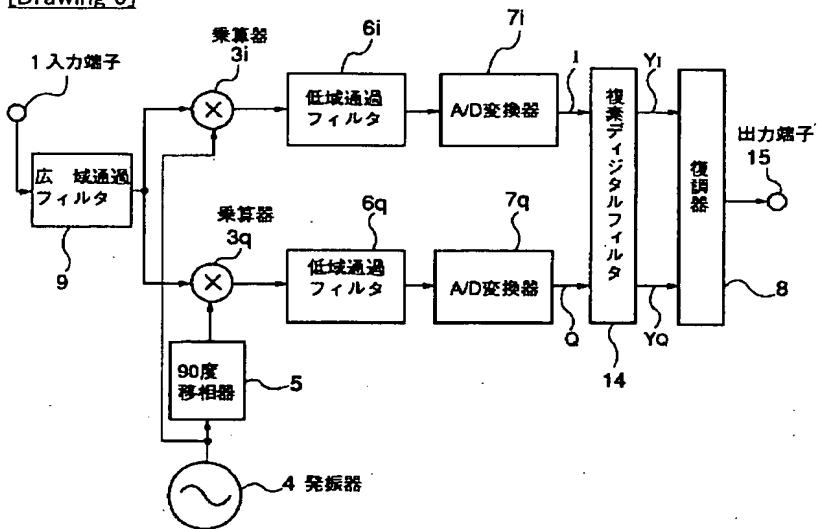
[Drawing 9]



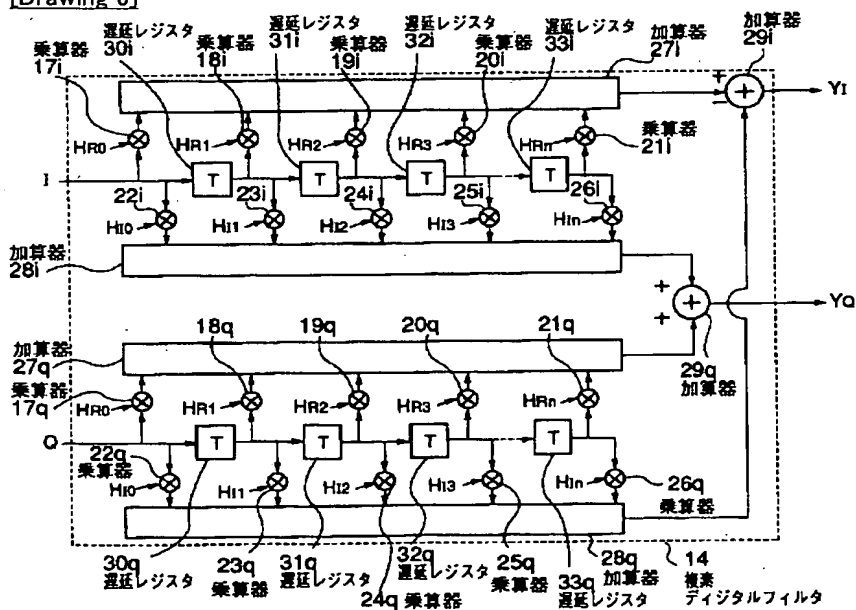
[Drawing 10]



[Drawing 5]



[Drawing 6]



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